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1. Your reference	P1346
2. Patent application number *(The Patent Office will fill in this part)*	0301257.2 21 JAN 2003
3. Full name, address and postcode of the or of each applicant *(underline all surnames)*	THE SECRETARY OF STATE FOR DEFENCE DSTL Porton Down Salisbury. Wiltshire. SP4 0JQ
Patents ADP number *(if you know it)*	548100l6
If the applicant is a corporate body, give the country/state of its incorporation	GB
4. Title of the invention	Apparatus for Collecting Particles
5. Name of your agent *(if you have one)*	Beckham Robert William
"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*	D/IPR Formalities Section Poplar 2 MoD Abbey Wood #2218 Bristol BS34 8JH. UK
Patents ADP number *(if you know it)*	84011972001

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number	Country	Piority application number *(if you know it)*	Date of filing *(day / month / year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application	Number or earlier application	Date of filing *(day / month / year)*

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if
a) any applicant named in part 3 is not an inventor, or
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11. I / We request the grant of a patent on the basis of this application.

Signature SSkelton

Mr S R Skelton

Date: 21 January 2003

12. Name and daytime telephone number of person to contact in the United Kingdom — Miss Laura Morrison 0117 91 30228

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DUPLICATE

APPARATUS FOR COLLECTING PARTICLES

The present invention generally concerns improvements to apparatus for collecting airborne particles. The present invention is particularly, although not exclusively, directed to apparatus for the collection of particles from an environment in which the temperature of ambient air is close to or even below, 0°C.

The separation of particles from air is often achieved by the use of cyclones that provide for rapid acceleration of the air whereby differential centripetal forces act to dislodge particles from the airflow. The collection of the separated particles, for example, for analysis, often requires that the particles be suspended in a minimum volume of a collection fluid, normally water. Apparatus providing this facility often employ an injection of water, from a reservoir associated with the cyclone, into the airflow within the cyclone body and/or the wetting of the cyclone body walls. Such apparatus may, for example, sample about 700 litres of air per millilitre of water.

A particular problem of these apparatus lies in the fact that, under certain environmental conditions, the small volume of injected collection fluid is susceptible to freezing through contact with a large volume of cold air passing into the cyclone body. In addition, where the apparatus is exposed to prolonged ambient cold, the collection fluid may also freeze within the reservoir.

Freezing of the collection fluid prevents the correct operation of the collection system and analysis of the type and concentration of particles in an environment. The problem therefore represents a severe limitation to the operation of these apparatus in

circumstances where there is a need to identify pathogenic threats in environments in which the temperature is close to or below 0°C.

One approach to the problem utilises a heater to heat the environment immediately ambient the apparatus. However, this approach is generally unsatisfactory especially where there is an urgent need to begin operation of an apparatus having had prolonged contact with a freezing environment.

Alternative approaches to the problem may provide antifreeze to the collection fluid or, additionally or alternatively, heat one or more of the cyclone body, reservoir and connecting lines. However, these approaches are complicated by problems involving sample integrity and analysis and the need to reengineer the cyclone or apparatus. In addition, heating of the cyclone body, reservoir and connecting lines may not adequately prevent freezing of the relatively low volume of injected collection fluid through contact with the large volume of cold air entering the cyclone.

The present invention generally seeks to overcome the problem of freezing of collection fluid, particular injected collection fluid, by providing more efficient means for heating air entering the cyclone.

Accordingly, the present invention provides apparatus for collecting particles from air, comprising a cyclone having air inlet and outlet means, means maintaining an airflow there through and means delivering a collection fluid from a reservoir to particles in or separated from the airflow in the cyclone, in which the air inlet means is associated with means for heating the incoming air.

The term "air inlet means", as used in this specification, includes any arrangement providing for the passage of air from the environment to the cyclone body. In particular, it will be appreciated that the air inlet means may comprise an elevated, annular air intake slot with connecting means, for example tubing, guiding the air to the cyclone body.

It will be understood, therefore, that the present invention includes within its scope heating means arranged on, within or around the air inlet means and, in particular, the intake slot and/or connecting means.

In some embodiments of the present invention, the heating means is co-axially mounted on or within the air inlet means. Preferably, the heating means is maintained in thermal contact with a portion of an exterior or interior surface of the air inlet means. The heating means may be mounted to the air inlet means so that, at least a portion of, their surfaces are touching. However, it will be apparent that a thermally conductive intervening element may also be provided between these surfaces. Of course, in these embodiments the air inlet means will, at least in part, be thermally conductive.

Alternatively, the heating means may be co-axially mounted within the air inlet means so as to heat the incoming air in the air inlet means directly. Preferably, the heating means is not in contact with the air inlet means. In some embodiments, therefore, the air inlet means may comprise a heat insulating material.

The heating means may comprise any suitable heating means and may, in particular, may be powered by a battery or other means. In a preferred embodiment, the heating means comprises a heating block, which is mounted in thermal contact with a thermally conductive portion of a cylindrical air inlet tube. The block, which is, for example, be circular or semi-circular in cross section, may thermally contact part or the whole of the circumferential surface of the portion.

The heating block may comprise a metal or metal alloy, such as brass, and one or more heating elements, such as those known to the art as "fire rods". However, other thermally conductive materials and heating elements may also be suitable for the practice of the invention.

The heating means may be mounted on or within the air inlet means by any suitable mounting means. In a preferred embodiment, the heating block is configured to slide or clamp onto the air inlet tube. The mounting means may additionally or alternatively, comprise abutments or indentations on the outer surface of the air inlet means.

The heating means may alternatively or additionally comprise means delivering air exciting the cyclone to the air inlet means. The exhaust air, which may be solely heated by the cyclone motor, or include an additional component from, say, the heating block may, for example, be delivered to an outer or inner tube surrounding or within the air inlet means before exiting the apparatus. Alternatively, the exhaust air may simply be delivered to a portion of an outer surface of the air inlet means.

The heating means may be associated with a temperature sensor for sensing the temperature of heated air entering or exiting the cyclone. Preferably, the heating means is associated with control means responsive to the temperature sensor whereby to control the extent of heating required to prevent injected collection fluid from freezing.

In some embodiments of the present invention, the apparatus comprise means for warming or heating the fluid collection reservoir and/or cyclone body. The second heating means may simply comprise means for trapping the exhaust air or heat from or the exhaust air.

The second heating means may therefore comprise enclosure means enclosing, at least in part, one or more of the fluid collection reservoir, cyclone body and air outlet means. Preferably, the enclosure means does not enclose the first heating means in which case the heating block, for example, is protected by a weatherproof container or jacket.

In some embodiments, however, the second heating means compliments the first heating means. In particular, exhaust air delivered to the air inlet means may be trapped by an enclosure also enclosing a portion, preferably a major portion, of the air inlet means. It will be apparent, however, that, in all embodiments of the present invention, at least a portion of the air inlet means will not be enclosed.

In a preferred embodiment of the present invention, the enclosure means comprise a rigid, box container equipped with closure means However, other enclosure means,

including framework structures supporting removable panels and/or insulating fabrics, may also be suitable.

As mentioned above, the enclosure means may enclose only part of the air outlet means so that only a portion of the heated air exiting the cyclone may be retained within the enclosure means. Alternatively, the enclosure means may not enclose the air outlet means and a portion of the heated air exiting the cyclone may be delivered to the enclosure means.

Preferably, however, the enclosure means wholly encloses the air outlet means and includes ventilation means, allowing ingress of ambient air and exit of heated air. The movement of ambient air into the enclosure prevents overheating of the sample and/or apparatus.

The ventilation means may simply comprise slots or apertures provided in, for example, the rigid box container. Preferably the ventilation means comprise louvres or slats which may, optionally, be rotatably mounted. The ventilation means may further comprise one or more blowers to assist in the movement of ambient air.

The ventilation means may also be controlled by second control means. In one embodiment, the enclosure means include one or more temperature sensors for sensing the temperature of the trapped air. In this embodiment, the second control means may be responsive to the temperature sensor or sensors so as to actuate, for example, the blowers.

The present invention substantially prevents freezing of injected collection fluid at ambient temperatures approaching −15°C and offers the advantage that particles may be rapidly sampled and analysed even after prolonged contact of the apparatus with freezing cold.

The invention further offers the advantage that existing particle collection apparatus are easily modified without the need for reengineering the apparatus. The incorporation of simple heating apparatus on or within the air inlet means avoids the need for antifreeze and provides an efficient and portable solution to the problem of freezing collection fluid on injection.

In addition, the retention of warm air, heated by the first heating means (and the cyclone motor), by simple enclosure means provides a cheap and portable solution to the problem of freezing of collection fluid in the reservoir. The present invention therefore avoids the necessity to heat air immediately ambient the apparatus and allows deployment of the whole apparatus outside an artificial environment, such as that provided by a heated vehicle. Further, the invention provides a heating solution for the collection fluid in which the integrity of the sample in the cyclone body is not prejudiced by, for example, excessive heat.

The present invention will now be described with reference to several embodiments and the following examples and drawings in which

Figure 1 is a section view of the apparatus of a preferred embodiment of the present invention;

Figure 2 is a part, plan section view of the apparatus of Figure 1; and

Figures 3 a) and b) are graphs showing the temperatures of various parts of the apparatus during operation at ambient temperatures of −9° to −12°C.

Having regard now to Figures 1 and 2, a low temperature, particle collection apparatus, generally designated 11, comprises a support member 12 housing a cyclone 13 having air inlet means, generally designated, 14 and air outlet means, generally designated, 15.

The air outlet means 15 comprise chambers 16, 17 provided in the support member 12, connecting the cyclone body 13 to an aperture 18 by tubes 19. One chamber 16 comprises a plenum chamber whilst the other houses a motor driven blower 20, which moves air from the air inlet means 14 through the cyclone body 13 towards the aperture 18.

The air inlet means 14 comprise a detachable, lozenge-shaped element 21 having an annular slot 22. The slot 22 admits air into a connecting tube 23 connecting the lozenge 21 with a tapered tube 24 entering the cyclone body 13. The tapered and connecting tubes 23, 24 are connected by a nut and screw arrangement.

The support member 12 also houses a number of peristaltic pumps 25 in fluid communication with a first reservoir 26 and a second, reserve reservoir 27. The first reservoir 26 contains an aqueous buffer solution, which is supplied, via tubing 28 and inlet tube 28a, to the airflow in the connecting tube 23 just above the cyclone body 13 and from the cyclone body 13 back to reservoir 26. Although sample collection is cyclic, leading to a more concentrated sample for analysis, the system includes a T-

joint in tubing 28 enabling a portion of the sample-containing buffer to be collected in second reservoir 27 as a back-up sample.

The support member 12 is arranged within a rigid, box container 29, having a removable panel or lid member (not shown). The box 29 has an aperture in its roof allowing for the exit, from the box 29, of the connecting tube 23 of air inlet means 14.

A brass heating block 30 having a centrally disposed, circular aperture (not shown) is arranged in contact with a portion of the connecting tube 23 of air inlet means 14 by sliding over the top of the tube 23 when the lozenge-shaped element 21 is detached. The heating block 30, which will not be described in detail here, comprises an arrangement of heating elements similar to those known in the relevant art. The underside of the heating block 30 contacts a thermally insulating mat 31, having a centrally disposed, circular aperture, provided on the upper surface of the upper wall of box 29. The heating block is fixed to the roof of the box 29 by screws 32, which engage threaded apertures provided around the circular aperture in the roof. The upper portion of the connecting means 23 of air inlet means 14 is lagged with a thermally insulating material 33. The heating element is connected to a mains supply via a power distribution module 34.

A thermostatic control 35 (not shown in Figure 2), having a temperature setting control, is also mounted on the lower surface of the roof of box 29. The thermostatic control 35 is connected to a temperature sensor 36 arranged to monitor the temperature of air exiting the cyclone body 13. The thermostatic control 35 controls the heating of the connecting tube 23 of air inlet means 14 by heating block 30

according to the whether the temperature of air exiting the cyclone sensed by the temperature sensor 36 is above or below a selected temperature.

A further thermostatic control 37, having a temperature setting control, is mounted on the inner surface of a wall of the box. The thermostatic control incorporates a temperature sensor, which monitors the temperature of the temperature of air in the box 29. Referring now to Figure 3, the thermostatic control 37 is connected (not shown) via power distribution module 34 to blowers 38 provided within opposing walls of box 29. The blowers 38, which are of a type commonly provided in windows, allow the entry of ambient air and the exit of heated air to the box 29. The blowers 38 are actuated by the thermostatic control 37 when the temperature sensor senses that the temperature of the trapped air is above the selected temperature setting.

The operation of the apparatus according to the present invention will be explained by reference to Figures 3 a) and b) of the drawings and the following Examples:

Example 1.

The heating block of the apparatus of Figure 1 was disconnected from its power supply. The cyclone was operated at an ambient temperature of –3°C and the temperature of the air (heated by the cyclone motor) in the enclosure monitored. The temperature of the enclosed air was found to be 20°C and water in the reservoir did not freeze. However, water injected into the cyclone body froze on contact with incoming air.

Example 2

The heating block of the apparatus of Figure 1 was reconnected to its power supply but the first control means disconnected. The cyclone was operated at temperatures above freezing and the ambient temperature and the temperature within the cyclone body monitored. After running for about 5 minutes the temperature within the cyclone body was found to be about 10°C above ambient temperature.

Example 3

The apparatus of Figure 1 was operated for about 1 hour with disconnected first control means, in a mobile field laboratory, at ambient temperatures of 0 to –4°C. The temperature of air within the enclosure was monitored. The heating block was found to prevent the formation of ice in the cyclone body whilst the second control means was found to maintain the temperature of air within the enclosure below 25°C.

Example 4

The apparatus of Figure 1 without a reservoir, was acclimatised to a climatic test chamber at an ambient temperature of –9°C. When the temperature of the apparatus had fully equilibrated with ambient temperature, the cyclone was started. The temperature of the air inlet tube and heating block and the temperature of air exiting the cyclone, and air in the enclosure was monitored. After about 15 minutes the temperature of the air in the enclosure had risen to about 15°C. The water reservoir was installed to the apparatus and continuous sampling begun.

Figures 2 and 3 show the variation in the temperature of the heating block, inlet tube temperature, enclosure and air temperature in the cyclone during sampling. The

heating block and control means was found to maintain the temperature of air exiting the cyclone at 10 to 13°C during a period of 2 hours. The sudden drops in the temperature of the enclosure (Figure 2) are due to the opening of the enclosure to install further collection fluid. It was noted that the second control means preventing overheating in the enclosure did not activate during the run, the temperature of enclosed air not exceeding 24°C.

Example 5

The apparatus of Figure 1 without a reservoir, was acclimatised to a climatic test chamber at an ambient temperature of −12°C. When the temperature of the apparatus had fully equilibrated with ambient temperature, the cyclone was started. After about 15 minutes the temperature of the air in the enclosure had risen to about 15°C. The water reservoir was installed to the apparatus and continuous sampling begun. Figure 3 shows the variation in temperature of air exiting the cyclone and enclosed air during sampling over a period of 30 minutes. It was noted that the second control means did not activate during the run, the temperature of the enclosed air not exceeding 24°C.

CLAIMS

1. Apparatus for collecting particles from air, comprising a cyclone having air inlet and outlet means, means maintaining an airflow there through and means delivering a collecting fluid from a reservoir to particles separated from the air flow in the cyclone, in which the air inlet means is associated with means for heating the incoming air.

2. Apparatus according to Claim 1, in which the heating means is in thermal contact with at least a portion of an exterior surface of the air inlet means.

3. Apparatus according to Claim 2, in which the heating means comprise a heating block having one or more heating elements.

4. Apparatus according to Claim 3, in which the heating block is configured so as to clamp or slide onto the air inlet means.

5. Apparatus according to Claim 3 or Claim 4, in which the heating block comprises a metal or metal alloy.

6. Apparatus according to any preceding Claim, in which the heating means is associated with control means responsive to sensing means sensing temperature of air entering or exiting the cyclone.

7. Apparatus according to any preceding Claim, further comprising enclosure means enclosing the cyclone body and/or the reservoir.

8. Apparatus according to Claim 7, in which the enclosure means comprise a rigid container having closure means.

9. Apparatus according to Claim 7 or Claim 8, in which the enclosure means comprises ventilation means.

10. Apparatus according to Claim 9, in which the ventilation means comprises a louvre.

11. Apparatus according to Claim 9 or Claim 10, in which the ventilation means further comprises a blower.

12. Apparatus according to Claim 11, in which the blower is associated with second control means responsive to sensing means sensing temperature within the enclosure means.

13. Apparatus substantially as hereinbefore described with reference to, and as shown in, the accompanying drawings.

ABSTRACT

Improved apparatus for collecting particles from air comprises a cyclone having air inlet and outlet means, means maintaining an airflow there through and means delivering a collecting fluid from a reservoir to particles separated from the air flow in the cyclone, in which the air inlet means is associated with means for heating the incoming air. The apparatus, which is optionally provided with enclosure means for trapping heat, prevents freezing of the collecting fluid at temperatures near to and even below 0°C.

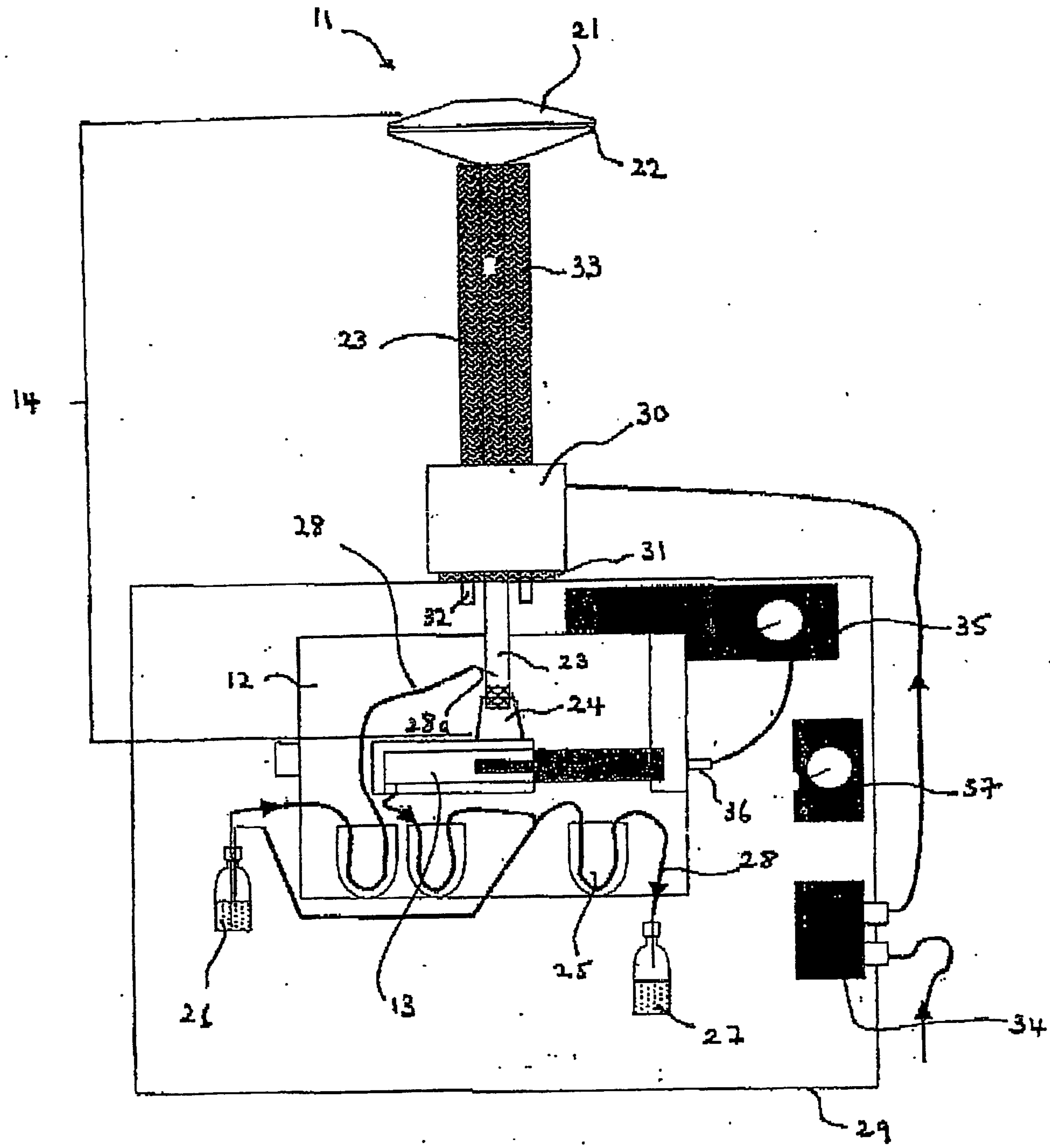

Fig. 1

1/3

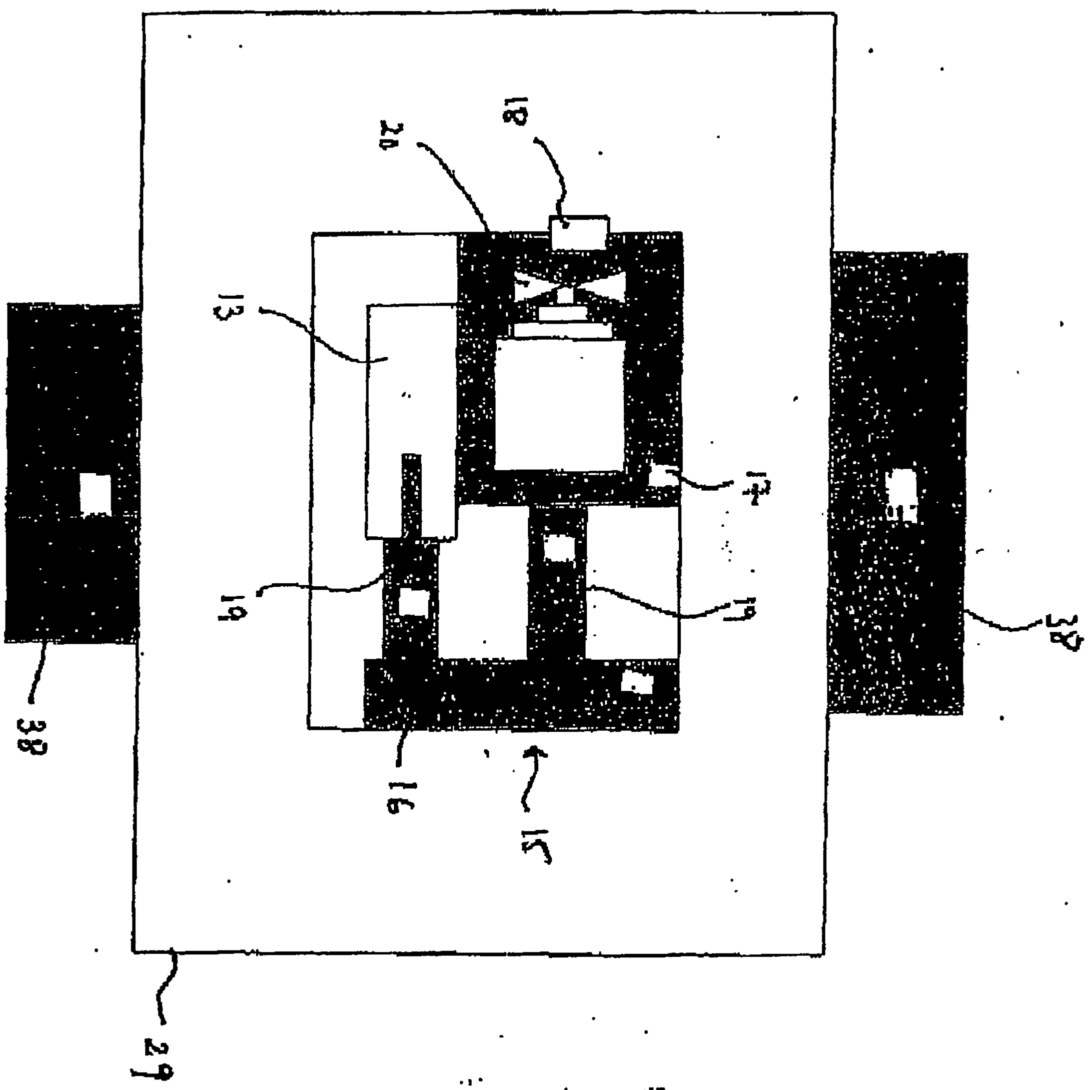

Fig. 2

3/3

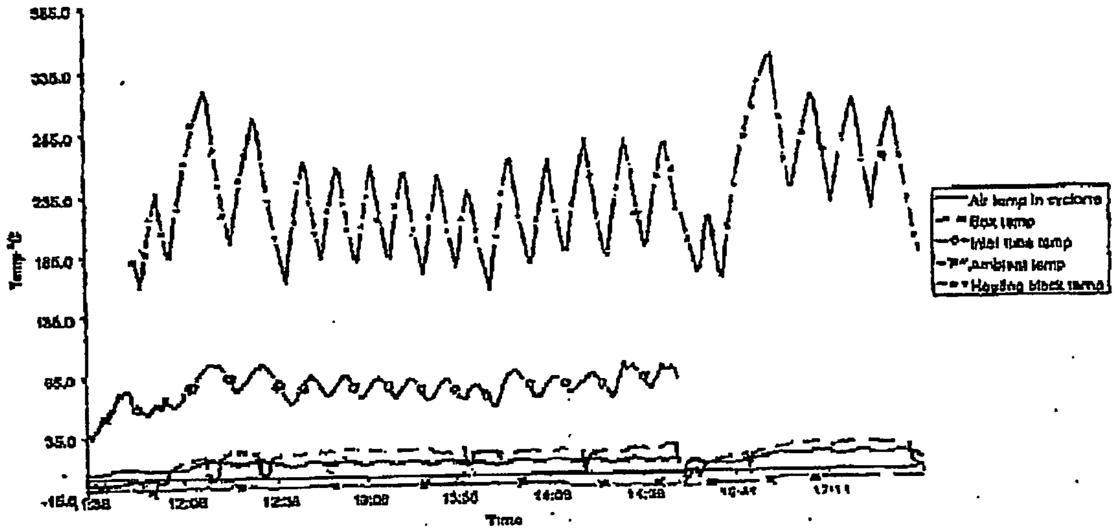

Fig. 3 a)

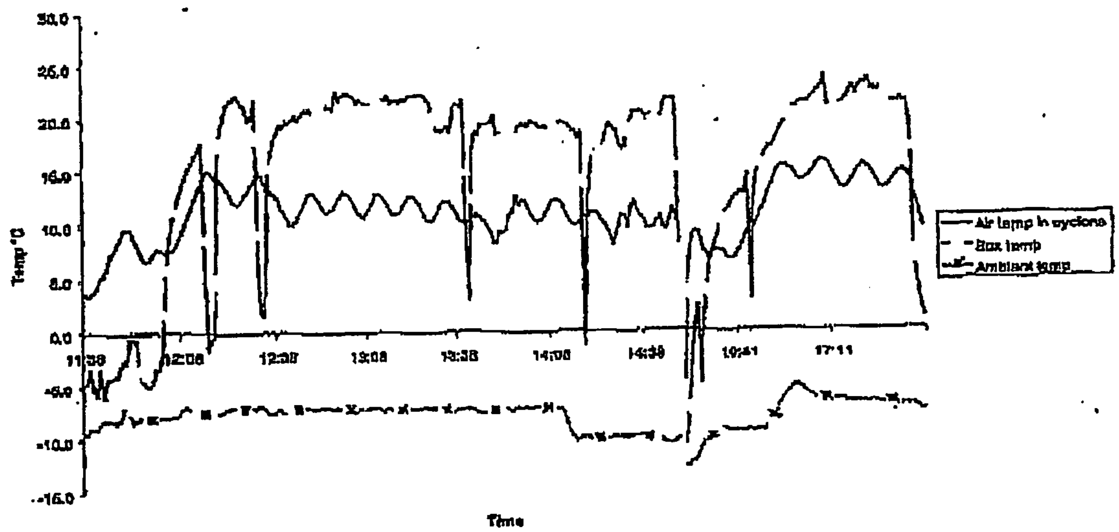

Fig. 3 b)